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ANAEROBIC TREATMENT OF LANDFILL LEACHATE

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ABSTRACT

Leachate generation at landfill sites continues to be a serious environmental problem. It is, therefore, necessary to address this with a suitable treatment scheme. The enhanced sanitary landfill (ESL) was developed at ORTECH (formerly Ontario Research Foundation) to provide leachate treatment and, at the same time, relatively fast land reclamation.

A pilot scale anaerobic digester was constructed and operated over a one-year period at the Region of Peel's Britannia Road Landfill Site in Mississauga to investigate the treatability of landfill leachate. In this paper, the results of the programme are presented and discussed.

INTRODUCTION

The sanitary landfill has been, and continues to be the principal means of municipal solid waste (MSW) disposal in Ontario. Through improved site selection, design and operation, both aesthetic and environmental problems have been reduced considerably. Despite these advances, groundwater contamination by leachate, and toxic and combustible gas generation continue to be problems at many landfill sites. Furthermore, the sanitary landfill is a land intensive process which can have significant economic and social consequences, particularly in growing urban areas. Uncontrolled generation of gas and leachate prevents timely reclamation of the land for subsequent sale or reuse. Although biogas abstraction systems have been installed at many landfills, there are several drawbacks, notably low methane recovery efficiency and limited control of methane generation rates. In recognition of the need for additional pollution control for sanitary landfills, ORTECH has developed the enhanced sanitary landfill.

THE ENHANCED SANITARY LANDFILL

The enhanced sanitary landfill concept is based on the premise that the landfill should be designed not as a dump, but as a waste treatment reactor. This reactor must be designed and operated in such a way as to

maximize the biodegradation rate of the MSW. It is believed that this can best be achieved by segregating the biodegradation process: hydrolysis/acidogenesis in the landfill and methanogenesis in a separate vessel. Treated leachate is recycled back to the landfill to continue the process. Saturation of the MSW is necessary to optimize the process, thereby taking advantage of the full landfill active surface area. By promoting methanogenesis in an external vessel, accelerated and more complete volatile-fatty-acid (VFA) conversion, and improved methane yields and production will result. It is estimated from published work that the organic fraction in the active landfill cell can be largely degraded within five years.

PHASE I: PILOT SCALE DEMONSTRATION

In order to further evaluate the concept of the enhanced sanitary landfill, a pilot facility was installed at Peel Region's Britannia Road sanitary landfill site in Mississauga. Phase I of this trial is a demonstration of the anaerobic treatability of leachate, in an external vessel. The treatment facility is illustrated in Figure 1.

The reactor was a 1.7 m^3, upflow, fixed film anaerobic digester, constructed of fibreglass reinforced polyethylene. The packing used was Statiflow's Modular PVC Media, providing over 90 m^2 of surface area per m^3 of volume. The reactor was operated with a 2 L/min recycle rate and at a temperature of ~ 35°C. Biogas was measured by a cumulative liquid displacement flowmeter amd vented to atmosphere. Leachate was pumped from a landfill works common sump to a 1 m^3 surface equalization tank. From the equalization tank, it was pumped through a hot water heat exchanger and brought to a temperature of 35°C. Treated leachate was discharged to the sanitary sewer. The leachate was found to have sufficient nitrogen content but was deficient in phosphorus. As a result, supplemental phosphorus was added in the form of dissolved di-ammonium phosphate.

The pilot facility was installed to provide the necessary design information to scale up for Phase II in which the complete ESL concept will be demonstrated. It was believed that a one-year operating duration would provide suitable data for this objective.

The anaerobic digester was seeded with anaerobic supernatant from Mississauga's Clarkson sewage treatment plant in October of 1987. Throughout the remainder of the year and into January of 1988, biogas production and COD reduction were extremely poor. It was felt that this was due, mainly, to an insufficient seeding of anaerobic bacteria. Consequently, in February, the reactor was reseeded with anaerobic sludge from Clarkson. Following this reseeding, digester performance quickly began to improve.

As unit performance continued to improve, the organic loading was increased in an attempt to determine the maximum tolerable leachate throughput. Table 1 is a summary of the digester performance data from June 2 to September 8, 1988.

At the time of writing this paper, the most current data available have the anaerobic digester operating at an organic loading of 2.7 kg COD/m^3 reactor/day, with a hydraulic retention time (HRT) of 2.3 days. COD and BOD removal are in the 80% and 85% range respectively. Biogas production is in the 1000 mL/min range with a methane content of between 70 and 75% (v/v).

The digester has also demonstrated the ability to remove some heavy metals from the leachate at varying removal efficiencies. Zn, B, Fe, Mn, Ca, Mg and Ni have all been removed from the wastewater at efficiencies ranging from 50-95%. It is believed that these metals have been bioaccumulated in the anaerobic sludge, and this has been confirmed by sludge metal scans which show very high levels of these particular metals.

Through the experimental program, the reactor has demonstrated extreme resilience to process upsets. First and foremost, the leachate feed to the digester has been variable. Figure 2 illustrates the heterogenous nature of leachate COD. Despite this, reactor performance did not appear to cycle. Moreover, other process upsets, such as temperature control failure and feed interruption for greater than 60 hours did not have a long-term effect on COD removal or biogas production. Within one or two days, the anaerobic digester was operating at the same efficiency as before the process upset.

This characteristic, along with the relatively high alkalinity of the Britannia leachate (> 3000 mg $CaCO_3$/L) made anaerobic digestion a particularly suitable technology for treating Britannia leachate. The results of the programme indicate that anaerobic treatment of leachate is a feasible and effective form of pollution control. Also, the biogas production rates and high methane concentration further demonstrate the high efficiency of this treatment alternative. In general, the results of this study have confirmed the Phase I objectives and lead to the necessity of a demonstration of the entire enhanced sanitary landfill scheme.

PHASE II: INTEGRATED ENHANCED LANDFILL SYSTEM DEMONSTRATION

With the successful completion of Phase I, ORTECH has proposed that Phase II be undertaken as a demonstration of the entire enhanced sanitary landfill concept. It would encompass construction of the landfill test cells, one enhanced, the other a control. Nominal dimensions would be 10 m x 10 m x 3 m deep. The pumping/recycling network would be installed prior to MSW landfilling. A 25 m^3 anaerobic digester would be constructed alongside the cell, based on the design information provided from Phase I. A comprehensive monitoring program, including stratigraphical, hydrogeological, physical chemical and biochemical analyses would be conducted during the estimated 2-3 year operating time. When leachate quality and gas production are indicative of landfill stabilization, recycling would be terminated and an intensive final assay conducted at the site to assess the final conditions of the landfill.

ACKNOWLEDGEMENTS

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TABLE 1 - Britannia Leachate Treatment Study:
Digester Performance Data Average - June 2 - September 8, 1988

BOD Removal (%)	COD Removal (%)	Organic Loading (kg COD/m^3 reactor/day)	HRT (days)	Biogas Production (mL/min)	Biogas Methane Content (% v/v)
83	74	1.8	3.7	689	72

FIGURE 1 - Enhanced Sanitary Landfill: Phase 1 Demonstration Facility

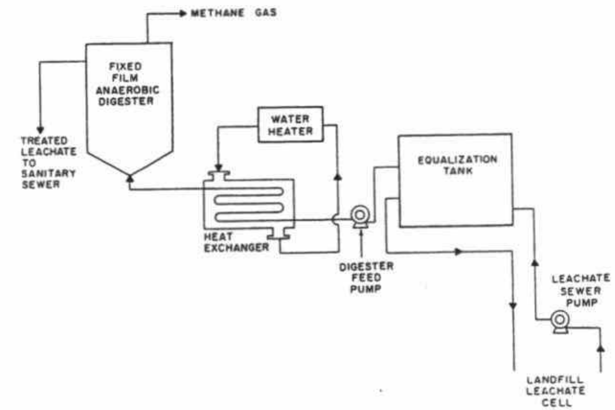

FIGURE 2 - Britannia Leachate Treatment Study